

The paraprocts are generally well developed, chitinized and fused with the bases of the cerci, although in the nymphs of some forms and also the adults of others they may be more distinctly separated. Frequently they bear copulatory appendages in the form of hooks, as in *Isoperla* sp. (Pl. II, Fig. 18), or of long processes which fit together into a spout-like organ (*Dictyopterygella*, teste Klapálek, '12). Crampton's figure of *Acroneuria brevipennis* shows a pair of small hooks on the paraprocts in addition to the larger ones borne by the supra-anal plate.

Owing to lack of material I have been unable to study satisfactorily the penis of the Plecoptera. When present it is usually single, but according to Crampton, the bipartite form occurs in some forms, such as *Nemoura completa* Walk. (l. c., Pl. II, Fig. 16). In this figure processes resembling parameres are represented. In some cases it is membranous and eversible, in others it is partly chitinized, and it may be provided with a virga, as in *Perlesta flavida* (Crampton, l. c., Pl. II, Fig. 14). In *Perla tristis* Hag. it is a large, stout structure of simple rounded form, with a rather large terminal aperture, (Pl. II, Figs. 19, 20). The distal part of the ejaculatory duct has longitudinally folded walls and is darker than the rest of the organ. There are no parameres nor other chitinous parts.

#### Embiidina.

The only species, males of which I have studied, is the widely distributed *Oligotoma saundersii* Westw., but the numerous figures in Enderlein's monograph of the order (Enderlein, '12) afford a basis for a more general survey of the genitalia of this group.

The most primitive form is undoubtedly the large South American *Clothoda nobilis* Gerst., which is remarkable for the symmetry of the terminal abdominal structures, and for the lack of the various copulatory processes, so strikingly developed in all the other genera. In most of the Embiids there is a shortening of the ninth abdominal tergum and an enlargement of the tenth, somewhat suggestive of the Dermaptera. In *Clothoda* the tenth tergum is short, symmetrical and entire, while in all the other genera it is more or less enlarged and deeply divided into two asymmetrical parts (hemitergites), which are sometimes completely separated. In the great

majority of forms each hermitergite bears a more or less hook-like copulatory appendage, but these may differ very greatly in form and position. In *Oligotoma saundersii*, e. g., the dextral hook is much longer and differently shaped from the sinistral one (Pl. I, Figs. 9 and 10).

The ninth sternum is entire and without styli, and, except in *Clothoda*, is asymmetrical, the apex being well to the left of the median line and bearing another copulatory process. The asymmetry also involves the cerci, which are two-segmented, without including the basipodites. These sclerites are generally inconspicuous, but in *Clothoda* they are well developed, extending mesad in the form of freely projecting plates, somewhat suggestive of the paraprocts of certain Plecoptera, such as *Perla*. One might, in fact, be tempted to interpret the latter as greatly enlarged cercal basipodites rather than as true paraprocts. In *Oligotoma* the left basipodite bears still another copulatory appendage on its inner side. These various copulatory appendages converge on the left side of the middle line, their position suggesting that in copulation the abdomen of the female is grasped by the male from the right side.

Of the supra-anal plate, paraprocts and penis I have been able to find nothing in *Oligotoma*. They must be extremely vestigial if present at all, although the paraprocts are quite distinct in the females of this order.

It is altogether probable that the special characteristics of the male Embiids, i. e., the asymmetry and the development of the various copulatory appendages, have been evolved within the history of the group itself, since its most primitive living member, *Clothoda*, is lacking in these very features. Accepting this view it is useless to attempt to homologise these processes with those of similar function occurring in other orders.

The male genitalia of the Embiidæ offer little or no evidence as to their relationships with other orders, but there is nothing in their structure to conflict with the view held by MacLachlan, Crampton and others that their nearest affinities are with the Plecoptera. In fact, in the development of copulatory appendages from a great variety of parts, they at least show similar tendencies to the Plecoptera, especially in the division of the tenth tergum into hermitergites, each bearing a hook, a feature which has already been noted in the case of the Plecopteran genus *Arcynopteryx*, and is by no means confined to that genus.

### Orthoptera.

In the Orthoptera there is a tendency toward a shortening of the posterior terga, which is most marked in the Acridoidea, while the anal plates are usually well developed but very variable in form. The supra-anal plate is frequently fused with the tenth tergum, but not overlapped nor replaced by the latter as in the Blattoidea, Mantoidea and Isoptera, although in certain Tettigonoidea (*Ceuthophilus*) the ninth tergum (more rarely the 8th) projects over the tenth and supra-anal plate, thus having the appearance of being the last dorsal segment. The cerci are with rare exceptions unsegmented and short, being frequently modified as claspers. A small cercal basipodite is usually present. The ninth sternum is generally entire, forming a hypandrium, but in the Acridoidea it is divided by a transverse suture, as in the Phasmoidea, the distal plate probably representing the fused coxites. Secondary subdivisions may also occur in some Tettigonoidea. In this superfamily styli are generally present, but they are absent in all the other groups.

Owing to the peculiar and often extremely complex structure of the genitalia it will be convenient to deal with these separately after having discussed the other structures with which we are concerned.

#### *The Terminal Segments, Cerci and Styli.*

TETTIGONOIDEA. In most of the long-horned grasshoppers the abdominal segments are not greatly specialized, the terga and sterna being distinct and separate, the latter rather feebly chitinized, and the spiracles occupying the pleural membrane. There is usually relatively little shortening of the 9th and 10th, although sometimes, as in *Ceuthophilus*, the 10th is small, subvertical and concealed by the projecting 9th tergum, which is thus commonly but erroneously termed the supra-anal plate by systematists. The true supra-anal plate is of variable size, but generally inconspicuous, and frequently fused with the tenth tergum in the adult insect. It is not divided transversely, or otherwise, as in many Acrididæ. The paraprocts are commonly lobe-like and but little chitinized. The ninth sternum is typically undivided, though indications of the coxites are sometimes seen in the more or less bifid caudal

margin of many forms, this feature being particularly noticeable in young nymphs and sometimes, as in species of *Ceuthophilus*, secondary subdivisions are present. Styli are present in the majority of genera, though frequently absent, as in many of the Rhabdiphorinæ, which in this respect, and also in the more convex and upturned ninth sternum, the unmodified cerci and the structure of the genitalia, approach the Grylloidea. The cerci are generally short, unsegmented and modified to serve as claspers in copulation, but in the Rhabdiphorinæ, with few exceptions, they do not function as such, being like those of the female, comparatively long, flexible and tapering, and covered with sensory hairs. In some species of this family, such as *Pristoceuthophilus cercalis* Caud., the cerci have a few small terminal segments, but this character, though an interesting exception to the general rule in the Orthoptera, is probably an atavistic one. A small cercal basipodite is sometimes, but not always, present. In the large membranous area between the paraprocts and the ninth sternum is the penis, which is described below.

In *Cyphoderris monstrosa* Uhl., (Pl. IV, Figs. 35, 36) an aberrant species, usually placed in the Stenopelmatinæ, a most remarkable modification of the genital structures is present. The ninth sternum is bent vertically upwards and closely applied to the end of the abdomen, which it covers below the paraprocts. Into the narrow pocket thus formed opens the genital passage, whose folded, membranous lips are the only representative of the penis, there being no chitinized parts. There is, however, in place of the titillators or parameres, a large process arising from the 9th sternum. It projects somewhat backward and is then sharply bent downward, terminating below in a pair of divergent spines. The dorsal surface also bears minute spinules. In a nearly full-grown male nymph of this species there is no indication of this structure, and the sternum, though bent up, is less closely applied to the body. In both adult and nymph there is a pair of stout, flattened styli, which, from their position, are at first sight, somewhat suggestive of titillators.

**GRYLLOIDEA.** In the crickets the abdominal segments are similar to those of the Tettigonoidea, except that the ninth sternum is smaller, more narrowed caudally, and envelopes the genitalia more closely, there being a smaller outlet for the

genital cavity; and there is no trace of styli. The inner surface of the sternum is covered by a much folded glandular epithelium. The cerci are not modified as claspers, and are longer, flexible, with long hairs and sensillæ, although unsegmented. There is a small external cercal basipodite. In all these respects they are approached by the Tettigoniid subfamily Rhaphidophorinæ. The anal plates are generally more prominent and heavily chitinized than in the Tettigonoidea. The supra-anal plate is undivided and is sometimes, as in *Gryllus* and *Nemobius*, indistinctly separated from the tenth tergum.

More important characters are found in the genitalia (q. v.)

TRIDACTYLOIDEA. The outstanding characteristics of the males of this group, apart from the penis, are the weakening and infolding of the posterior abdominal terga, particularly those of segments 8, 9 and 10, which are more or less concealed by the overlapping 7th tergum, the dorsal lengths of segments 8 and 9 being greatly reduced by the obliquity of their hind margins; the styliform and sometimes two-jointed cerci, the long moveable processes of the paraprocts and the absence of true styli.\*

In *Tridactylus apicalis* Say the terga are mesially grooved with steeply sloping sides, and the 9th is divided and concealed by the 8th, except towards the lateral margins. The 10th is much larger but is likewise divided by the median groove, and the supra-anal plate is also sulcate with only the lateral margins strongly chitinized. The paraprocts are chitinized and bear a pair of slender, styliform processes, like those of the female. The sterna are wider than the terga, the 9th forming a flattened and undivided hypandrium.

In *Ripipteryx* the general characteristics of the terga are similar but with marked variations according to the species.

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\* Crampton ('20d) considers these styliform appendages as probably true styli, belonging to seg. 11, the paraprocts representing the coxites of that segment. If these processes were true styli we should expect to find them in some other groups of Orthopteroid insects besides the Tridactylidæ, as well as in the Thysanura, in which styli sometimes occur on nearly all of the abdominal segments. It is noteworthy, however, that even in such Thysanura as *Machilis*, in which the styli are seen in their most primitive and best developed condition, they are absent from the 10th segment and paraprocts. The development of styliform processes in connection with the genitalia is very common in insects and the presence of these processes in this single small group of Orthoptera is an insufficient basis for speculation as to their origin.